YEAR 2: ELECTRICITY AND MAGNETISM

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BOOKS

David J Griffiths, Introduction to Electrodynamics, 3rd ed.

I.S. Grant and W.R. Phillips, Electromagnetism, 2nd ed.

B.I. Bleaney and B. Bleaney, Electricity and Magnetism, 3rd ed.

J.D. Jackson, Classical Electrodynamics, 3rd ed.

S. Ramo, J.R. Whinnery and T. Van Duzer, Fields and Waves in Communications Electronics, 3rd ed.

SYNOPSIS

I. ELECTROSTATICS

A. MOSTLY REVISION

1. charge, Coulomb's law, superposition

2. electric field, field lines

3. Gauss' law

Example

4. curl $\vec{E} = 0$

5. electrostatic potential

6. Poisson and Laplace equations

7. summary so far

8. electrostatic boundary conditions

9. conductors

Example

B. POISSON AND LAPLACE EQUATIONS

1. the equations and uniqueness

2. Poisson: 1D

3. Laplace 3D: Cartesian coordinates, field in a slit

4. Laplace 3D: spherical polars, spherical conductor in a uniform $\vec{E}$ field

5. Laplace 3D: cylindrical polars, cylinder with a fixed surface charge density

C. MULTIPOLE EXPANSION

1. electric dipole

2. the multipole expansion

D. POLARIZABLE MATERIALS

0. vector identities

1. polarization: definition and physical origins

2. bound charge

3. Gauss' law in dielectrics and $\vec{D}$

4. linear dielectrics and ϵ

5. field due to a point charge in a linear dielectric

6. boundary conditions on $\vec{D}$, $\vec{E}$ and V at a dielectric boundary

Examples

II. STEADY CURRENTS AND MAGNETISM

A. MOSTLY REVISION

0. vector identities

1. currents, charge conservation

2. force on a current carrying conductor

3. Biot-Savart law

4. div$\vec{B} = 0$

5. curl $\vec{B}$ and Ampere's law

6. magnetostatic boundary conditions

7. summary of Maxwell with no time dependence

B. MAGNETIC DIPOLES AND THE MULTIPOLE EXPANSION

1. magnetic vector potential

2. summary of formulas for $\vec{B}$, $\vec{A}$, $\vec{J}$

3. multipole expansion of $\vec{A}$ and the magnetic dipole

C. MAGNETIZABLE MATERIALS

1. magnetization, definition and physical origins

2. bound currents

3. Ampere's law in magnetizable materials and $\vec{H}$

4. linear materials and the relative permeability, μ

5. boundary conditions for $\vec{B}$, $\vec{H}$ in a linear medium

6. magnetic scalar potential

7. permanent magnets

D. ELECTRODYNAMICS

1. Faraday's law

2. Maxwell's correction to Ampere's law: the displacement current

3. polarization current

III. ELECTROMAGNETIC WAVES

A. PLANE WAVES IN DIELECTRICS

1. Maxwell's equations in dielectrics

2. wave equation

3. plane wave solutions

(a) waves are transverse (b) polarization (c) dispersion relation (d) ratio of amplitudes of $\vec{E}$ and $\vec{B}$ fields (impedance)

B. PLANE WAVES IN CONDUCTORS

1. Maxwell's equations

2. good and poor conductors

(a) decay time of charge distribution vs period of em wave (b) conduction vs displacement current (c) numbers

3. wave equation

4. plane wave solutions

(a) waves are transverse (b) polarization (c) dispersion relation (d) skin depth (e) ratio of amplitudes of $\vec{E}$ and $\vec{B}$ fields (impedance) (f) good and poor conductor limits

C. ENERGY IN ELECTROMAGNETIC FIELDS

1. conservation of energy ... from which we get

(a) the Poynting vector (b) stored energy in em field

2. check that $\frac{1}{2}\int \vec{D}.\vec{E}d\tau = \frac{1}{2}\int \rho V d\tau$

3. example: charging a capacitor

4. radiation pressure

D. REFLECTON AND REFRACTION OF ELECTROMAGNETIC WAVES

1. normal incidence

2. general incidence

(a) laws of reflection and refraction (b) Fresnel equations: $\vec{E}$ in plane of incidence (c) Fresnel equations: $\vec{E}$ perpendicular to plane of incidence (d) check conservation of energy

3. physical consequences of the Fresnel equations

(a) Brewster angle (b) total internal reflection (c) reflection from a metal

E. FREQUENCY DEPENDENCE OF THE REFRACTIVE INDEX (DISPERSION)

F. PLASMAS

1. introduction, definition and examples

2. refractive index (method 1)

3. refractive index (method 2)

4. why are methods 1+2 alternatives?

5. example: dispersion and measuring the distance to pulsars

G. RADIATION

1. retarded potentials

2. electric dipole radiation and antennas

IV. GUIDED WAVES

A. TRANSMISSION LINES

1. introduction

2. Telegraph equations, velocity, impedance

3. boundary between transmission lines

4. termination by a load

5. coaxial line

6. em waves on a coaxial line

B. WAVEGUIDES